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POLYSACCHARIDE-BASED NANOCOMPOSITES FOR GENE DELIVERY AND TISSUE ENGINEERING

Edited by
SHOWKAT AHMAD BHAWANI
ZOHEB KARIM
MOHAMMAD JAWAID

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Polysaccharide-Based Nanocomposites for Gene Delivery and Tissue Engineering

Edited by

Showkat Ahmad Bhawani
Faculty of Resource Science and Technology, Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak, Malaysia

Zoheb Karim
MoRe Research AB, Sweden

Mohammad Jawaid
Biocomposite Technology Laboratory, Institute of Tropical Forestry and Forest Products (INTROP), University Putra Malaysia (UPM), Serdang, Selangor, Malaysia

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About the book

Description

Polysaccharide-Based Nanocomposites for Gene Delivery and Tissue Engineering presents quantitative background on new polysaccharide nanocomposites in a clear and logical way, highlighting the most exciting applications in gene delivery and tissue engineering and their progress. The book focuses on the different types of polysaccharide nanocomposites for gene delivery and tissue engineering and covers

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Key Features

- Presents quantitative background on new polysaccharide nanocomposites for advanced medicine
- Focuses on polysaccharide nanocomposites in relation to gene delivery and tissue engineering
- Highlights the most exciting, leading-edge applications in gene delivery and tissue engineering

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Editors

Showkat Ahmad Bhawani

Faculty of Resource Science and Technology, Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak, Malaysia

Zoheb Karim

MoRe Research AB, Sweden

Mohammad Jawaid

Biocomposite Technology Laboratory, Institute of Tropical Forestry and Forest Products (INTROP), University Putra Malaysia (UPM), Serdang, Selangor, Malaysia

Contributors

Aarzoo Department of Chemistry, School of Chemical and Life sciences, Jamia Hamdard, New Delhi, India

Sadaf Afrin Department of Chemistry, Faculty of Sciences, Aligarh Muslim University, Aligarh, India

Akil Ahmad School of Industrial Technology, Universiti Sains Malaysia, Penang, Malaysia

Asrar Ahmad Center for Sickle Cell Diseases, College of Medicine, Howard University, Washington, DC, United States

Khalid M. Alotaibi Department of Chemistry, College of Science, King Saud University, Riyadh, Kingdom of Saudi Arabia

Mohammad Omaish Ansari Center of Nanotechnology, King Abdul Aziz University, Jeddah, Saudi Arabia

Mohd Saquib Ansari Department of Biomedical Sciences, Shaheed Rajguru College of Applied Sciences for Women, University of Delhi, New Delhi, India

M. Tarik Arafat Department of Biomedical Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh

Maya Asyikin Mohamad Arif Faculty of Resource Science and Technology, University Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia

Mohd Razip Asaruddin Faculty of Resource Science and Technology, Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak, Malaysia

Mohammad Ashfaq BS Abdur Rahman Crescent Institute of Science and Technology, Chennai, India

Erkan Türker Baran University of Health Sciences Turkey, Institute of Health Sciences, Department of Biomaterials; University of Health Sciences Turkey, Institute of Health Sciences, Department of Tissue Engineering, Istanbul, Turkey

Sunita Barik Department of Chemistry, Saraswati Degree Science College, Cuttack, Odisha, India

Anant Narayan Bhatt Institute of Nuclear Medicine and Allied Sciences, Defence Research and Development Organization, New Delhi, India

Showkat Ahmad Bhawani Faculty of Resource Science and Technology, Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak, Malaysia

Anuradha Biswal Department of Chemistry, Veer Surendra Sai University of Technology, Sambalpur, Odisha, India

Afzal Hussain Department of Pharmacognosy, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia

Mohamad Nasir Mohamad Ibrahim School of Chemical Sciences, Universiti Sains Malaysia, Penang, Malaysia

Iqbal I.M. Ismail Department of Chemistry, Faculty of Science, King Abdul Aziz University, Jeddah, Saudi Arabia

Zoheb Karim MoRe Research AB, Sweden

Mohd Jahir Khan School of Biotechnology, Jawaharlal Nehru University, New Delhi, India

Abhishek Kumar Department of Biomedical Sciences, Shaheed Rajguru College of Applied Sciences for Women, University of Delhi; Institute of Nuclear Medicine and Allied Sciences, Defence Research and Development Organization, New Delhi, India

Vannessa Lawai Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Sarawak, Malaysia

Zainab Ngaini Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Sarawak, Malaysia

Mehvish Nisar Faculty of Resource Science and Technology, Universiti Malaysia Sarawak (UNIMAS), Kota Samarahan, Sarawak, Malaysia

Mohammad Oves Center of Excellence in Environmental Studies, King Abdulaziz University, Jeddah, Saudi Arabia

Md. Wahidur Rahman Department of Biomedical Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh

Mohd Rashid School of Chemical Sciences, Universiti Sains Malaysia, Penang, Malaysia

Chinmayi Rath Department of Chemistry, Saraswati Degree Science College, Cuttack, Odisha, India

Mohd Ahmar Rauf Use-Inspired Biomaterials & Integrated Nano Delivery (U-BiND) Systems Laboratory, Department of Pharmaceutical Sciences, Eugene Applebaum College of Pharmacy and Health Sciences, Wayne State University, Detroit, MI, United States

M. Samim Department of Chemistry, School of Chemical and Life sciences, Jamia Hamdard, New Delhi, India

Rahul Kumar Sharma Department of Chemistry, Government Shyam Sundar Agrawal PG College, Sihora, Madhya Pradesh, India

Laishram Rajendra Kumar Singh Dr. B.R. Ambedkar Center for Biomedical Research, University of Delhi, New Delhi, India

Sarat K. Swain Department of Chemistry, Veer Surendra Sai University of Technology, Sambalpur, Odisha, India

Aydin Tahmasebifar University of Health Sciences Turkey, Institute of Health Sciences, Department of Biomaterials; University of Health Sciences Turkey, Institute of Health Sciences, Department of Tissue Engineering, Istanbul, Turkey

Abu Tariq Department of Chemistry, Aligarh Muslim University, Aligarh, Uttar Pradesh, India

Mohiuddin Khan Warsi Department of Biochemistry, College of Science, University of Jeddah, Jeddah, Saudi Arabia

Asim Ali Yaqoob School of Chemical Sciences, Universiti Sains Malaysia, Penang, Malaysia

Bengi Yilmaz University of Health Sciences Turkey, Institute of Health Sciences, Department of Biomaterials; University of Health Sciences Turkey, Institute of Health Sciences, Department of Tissue Engineering, Istanbul, Turkey

Editors' biographies

Dr. Showkat Ahmad Bhawani is presently working as an Associate Professor at the Department of Chemistry, Faculty of Resource Science and Technology, UNIMAS Malaysia. He received his Ph.D. in Applied Analytical Chemistry from Aligarh Muslim University, Aligarh, India. He is working on the synthesis of molecular imprinting polymers for the removal/extraction of dyes, fungicides, and various natural products from environmental and biological samples. In addition to this, he is working on the development of new test methods and determining standard conditions for analysis (separation, isolation, and determination) of various analytes from environmental and biological samples. He is involved in the analysis of samples such as surfactants, amino acids, drugs, vitamins, sugars, and metal ions. He has edited two books and has written 12 book chapters, and he has published more than 40 papers in various journals. He is a lifetime member of the Asian Polymer Association and an editorial board member of several journals.

Dr. Zoheb Karim worked as Senior Researcher at MoRe Research Ornskoldsvik AB. His current research is process-property-application correlation understanding of nanocellulose (crystals and fibers)-based assembled dimensional structures. Fabrications of functionally and structurally sound dimensional architecture for a predefined application using a best appropriate route and starting nanocellulose (required intrinsic properties) is another goal of his research. Recently, he patented a mechanism of metal ions removal by nanocellulose-based functionalized membranes with tailored pore-size which form metal ions-cluster on membranes and help to remove metal ions in high capacity (Patent application no. 1657849-9, AWAOATENT AB). Dr. Karim carried out his postdoctoral research at KTH Royal Institute of Technology Stockholm, Sweden, and before that he worked as a researcher at Luleå University of Technology, Sweden. His research has been supported by some well-known funding agencies such as the European Commission (NanoSelect under the 7th Framework Programme), Kempe Foundation, Mistra Foundation (MisraTerraClean), R&D Council of Processum, etc. He has given various plenary and invited talks related to his research interest in various reputed institutes including the University of Oxford, Imperial College London, Indian Institute of Technology Delhi, University of Guelph, EMPA-Swiss Federal Laboratory of Material Sciences and Technology, etc. He attended various international and national conferences/symposiums/workshops/invited lecturers around the world to present his research works. He is a member of the International Association of Advanced Materials, the Technical Association of Pulp and Paper Industry (TAPPI), and Sveriges Ingenjörer. Moreover, he organized two workshops at Lueå University of Technology Luleå in 2013 and 2014. He was a member of the International Committee of Biomaterials for Tomorrow, B4T (2018) organized by Mahatma Gandhi University, India.

At the same time, he was also a member of an international advisory committee of SafeBioPack (2018) organized by the Institute of Tropical Forestry and Forest Products (INTROP), University Putra Malaysia. Currently, he is also serving as an external expert/consultant of an Egypt-based company, inTEXive® (intexive.com). He has published about 31 peer-reviewed research articles of international repute and 10 book chapters with well-known publishers such as Elsevier, Springer Nature, CRC Press, TAPPI Press, and World Scientific. He also won the best paper award in 2012, awarded by Aufau Periodicals Publication USA.

Dr. Mohammad Jawaid is currently working as a Senior Fellow (Professor) at Biocomposite Technology Laboratory, Institute of Tropical Forestry and Forest Products (INTROP), University Putra Malaysia (UPM), Serdang, Selangor, Malaysia, and also has been a Visiting Professor at the Department of Chemical Engineering, College of Engineering, King Saud University, Riyadh, Saudi Arabia since June 2013. He has more than 20 years of experience in teaching, research, and industries. His area of research interests includes hybrid composites, lignocellulosic reinforced/filled polymer composites, and advanced materials: graphene/nanoclay/fire retardants, modification and treatment of lignocellulosic fibers and solid wood, biopolymers and biopolymers for packaging applications, nanocomposites and nanocellulose fibers, and polymer blends. So far, he has published 40 books, 65 book chapters, more than 350 peer-reviewed international journal papers, and several published review papers in "Top 25 Hottest Articles" in Science Direct during 2013–19. He also obtained two patents and six copyrights. He has Scopus H-index-55 (total citation 14171) and in Google scholar H-index-66 (total citation 20242). He is founding Series Editor of the Composite Science and Technology Book Series from Springer Nature, also Series Editor of *Springer Proceedings in Materials*, Springer Nature, and an International Advisory board member of the Springer Series on Polymer and Composite Materials. He worked as a guest editor on special issues of *SN Applied Science*, *Frontiers in Sustainable Food Systems*, *Current Organic Synthesis and Current Analytical Chemistry*, *International Journal of Polymer Science*, and *IOP Conference Proceeding*. He is also an Editorial Board Member of the *Journal of Polymers and the Environment*, *Journal of Plastics Technology*, *Applied Science and Engineering Progress Journal*, *Journal of Asian Science*, *Technology and Innovation*, and *Recent Innovations in Chemical Engineering*. In addition, he is a reviewer of several high-impact international peer-reviewed journals of Elsevier, Springer, Wiley, Saga, ACS, RSC, Frontiers, etc. Presently, he is supervising 12 Ph.D. students (five as Chairman, and seven as Member) and six Master's students (one as Chairman, and five as Member) in the fields of hybrid composites, green composites, nanocomposites, natural fiber-reinforced composites, nanocellulose, etc. Twenty-six Ph.D. and 13 Master's students graduated under his supervision in 2014–20. He has received several research grants at university, national, and international levels on polymer composites of around 3 million Malaysian ringgits (USD 700,000). He also delivered plenary and invited talks in international conferences related to composites in India, Turkey, Malaysia, Thailand, the United Kingdom, France, Saudi Arabia, Egypt, and China. Besides that, he is a member of technical committees of several national and international conferences on composites and material science. Recently, Dr. Mohammad

Jawaid received the Excellent Academic Award in the Category of International Grant-Universiti Putra Malaysia—2018 and also the Excellent Academic Staff Award in Category of industry High Impact Network during Community and Industry Network (ICAN 2019). Beside that he also won Gold Medal during JINM Showcase under Community and Industry Network Category at Universiti Putra Malaysia, Malaysia. He also received the Publons Peer Review Awards 2017, and 2018 (Materials Science), Certified Sentinel of Science Award Recipient—2016 (Materials Science) and 2019 (Materials Science and Cross Field). He is the winner of the Newton-Ungku Omar Coordination Fund: UK-Malaysia Research and Innovation Bridges Competition 2015. Recently he was recognized with a Fellow and Chartered Scientist Award from the Institute of Materials, Minerals and Mining (IOM), UK. He is also a lifetime member of the Asian Polymer Association, and the Malaysian Society for Engineering and Technology. He has professional membership of the American Chemical Society (ACS) and the Society of Plastics Engineers (SPE), USA.

Preface

This book provides solid, quantitative descriptions and reliable guidelines, reflecting the maturation and demand of the field and the development of new polysaccharide nanocomposites. It focuses on the different types of polysaccharide nanocomposites of cellulose, chitosan, alginate, etc. for gene delivery and tissue engineering. The book also covers polysaccharide hydrogels for tissue engineering and polysaccharide magnetic nanocomposites for gene delivery and highlights the most exciting applications in the field of gene delivery and tissue engineering. This book will be of interest to researchers working in the fields of material science, biomaterials, regenerative medicines, drug delivery, tissue engineering, polymer science/chemistry, and chemical engineering, and in the polymer industry. It will be useful for scientists working on polysaccharide nanocomposites for gene delivery and tissue engineering. The book will be very helpful for students in the development of new polysaccharide nanocomposites as well as graduates in polymer technology, biomedical science, and biotechnology.

The two introductory chapters cover basic information about polysaccharides and nanocomposites, to provide a foundational understanding. The second section of this book covers chitosan and its derivatives-based dimensional frameworks as carriers for gene delivery, alginate- and hyaluronic-based hydrogels for tissue engineering, heparin- and cellulose-based nanocomposites for and dextran, pullulan, gellan, xanthan, and xanthun gum-based nanocomposites for tissue engineering applications. The last section describes polysaccharide-based 3D bioprinter inks for tissue engineering, polysaccharide-based nanocomposites for gene delivery, chitosan- and starch-based nanocomposites for gene delivery, and hyaluronic acid magnetic nanocomposites for gene delivery.

Finally, we assure the readers that the information provided in this book can serve as a very important tool for anyone wishing to select/design polysaccharide-based nanocomposites to fulfil the requirements of gene delivery and tissue engineering applications. We are grateful to all the authors who contributed chapters to this book and who helped to turn our thoughts into reality. Lastly, we are grateful to the Elsevier team for their continuous support at every stage to make it possible to publish on time.

Showkat Ahmad Bhawani
Zoheb Karim
Mohammad Jawaid

Polysaccharides

1

Sadaf Afrin[a] and Zoheb Karim[b]
[a]Department of Chemistry, Faculty of Sciences, Aligarh Muslim University, Aligarh, India, [b]MoRe Research AB, Sweden

1.1 Introduction

Natural polysaccharides are generally constituted of simple carbohydrates with long chain molecules attached via glycosidic linkages. Carbohydrates are made up of aldehydes or ketones, and have multiples hydroxyl groups. They make up the majority of organic matter and play a crucial role in human life. Carbohydrates serve as energy stores, fuel, and various metabolic intermediates. In parallel, various sugars like ribose and deoxyribose form part of the structural framework of RNA and DNA. Polysaccharides are also present in the cell walls of bacteria and plants, and cellulose is the main constituent of plant cell walls [1, 2].

The most authentic classification performed for polysaccharides is based on degree of polymerization (DP). Polysaccharides may reach a DP of 10^5, whereas, by definition, the maximum DP for oligosaccharides is 10. Hence, by convention, compounds having a DP of 11 or more are designated polysaccharides. A monosaccharide is a monomer of saccharides, and a disaccharide is two conjugated monomers [1, 3].

Many studies are available related to the general introduction of polysaccharides, their chemical structures, chemical compositions, methods of isolation, types, etc. [4–7]. Hence, in this chapter, a very interesting aspect is explained: the nano-form of these polysaccharides, which is an area of emerging interest in scientific studies. Very few studies in the literature have been summarized related to nano-polysaccharides characterization, the isolation process, and their properties and applications. Consequently, this chapter explains the collective efforts and provides a summary of nano-polysaccharide understanding and their utilization in various applications.

1.2 Natural polysaccharide nanomaterials

Polysaccharides are molecules composed of monomer sugar units linked by glycosidic bonds; this bond is responsible for the attachment of monomers and forms polymers. They are the most abundant natural polymer on Earth [8, 9]. The amount of polysaccharide produced by plants per year exceeds by several orders of magnitude the synthetic production by the chemical industry [10]. Natural polysaccharides (Table 1.1)

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